

Page Denied

Next 1 Page(s) In Document Denied

HIGHER CHEMICAL ENGINEERING EDUCATION IN THE**U.S.S.R.****By Prof. N.M. Zhavoronkov****Director of the Mandelstey Chemical Engineering Institute
Moscow.**

At the present time in the absence of a chemical industry no progress is conceivable in any branch of the national economy. That is why in every country throughout the world such importance is attached to advances in the science of chemistry and the chemical industry.

The Soviet Union inherited from tsarist Russia a backward chemical industry devastated by war. Pre-revolutionary Russia was fifth among the chief industrial countries of the world. Approximately four per cent of the world's total industrial output was manufactured in Russia. The output of chemical products was relatively even smaller. In 1913 ^{12.1} 121,000 tons of sulphuric acid, 51,100 tons of caustic soda, 160,000 tons of soda ash, 6 49,000 tons of inorganic fertilizers and 1,520,000 tons of cement were produced on Russian territory. Coke production amounted to 4,443,000 tons. Many of the most important chemical products were not manufactured at all or manufactured in extremely small quantities. The greater part of the chemical enterprises were located in the Western and Southern regions of the country and suffered the heaviest damage during the first world war and the civil war that followed. The country had actually to create a new chemical industry in order to meet the immediate

requirements of the national economy for chemical products.

By 1927-28 reconstruction of the chemical industry was completed and chemical production exceeded the 1913 level. During the first five-year plan intensive construction of new chemical plants was begun. Commencing with 1928 hundreds of new large-scale chemical plants and mining-and-chemical enterprises were built, and old plants were reconstructed and enlarged. The inorganic fertilizer industry can serve as an example of the growth of the Soviet chemical industry as a whole.

Before the revolution at the few existing plants the annual output of superphosphate and ground phosphates, mainly from imported phosphate rock, was only about 60,000 metric tons. Old Russia did not produce nitrogen and potassium fertilizers at all, except for a small quantity of coke-gas ammonium sulphate.

In the early 1930's and in later years large plants for manufacturing superphosphates were built. Many phosphate raw material deposits were discovered, explored and put into operation. The most important of these are the apatite deposits in Khibini on the Kola Peninsula and the phosphate rock of the Kara-Tau mountains in the Kazakh S.S.R. An outstanding event was the discovery of practically inexhaustible deposits of potassium salts /sylvinite and carnallite/ in the Solikamsk and Bereznikov regions of the Northern Urals. A huge potassium fertilizer industry was created on the basis of these deposits.

-3-

Large plants for the production of synthetic ammonia and ammonia fertilizers were built in various regions of the country -- in the Urals, the Ukraine, Western Siberia, Uzbekistan and the Transcaucasian Republics. In 1940 the production of inorganic fertilizers exceeded 3,000,000 metric tons, and in 1956 the figure reached 10,000,000 tons.

Simultaneously other branches of the chemical industry were expanded, i.e. production of mineral acids, alkalis and salts, plastics, organic dyes, varnishes and paints, synthetic rubber, synthetic fibres and synthetic ethyl alcohol, basic organic syntheses products, chlorine and its derivatives and many other products. Huge coke by-product plants, oil processing plants and cement plants, structural and refractory ceramic works, factories producing china for domestic uses and for the electrical industry, glass works, etc., were erected. In 1956,

4,800,000 tons of sulphuric acid, 681,000 tons of caustic soda, 1,545,000 tons of soda ash, 77,000 tons of organic dyes and 24,800,000 tons of cement were produced in the U.S.S.R. Coke production reached the 46,600,000 ton mark and there was a corresponding growth of coke by-products production. A large-scale chemical machine and apparatus-manufacturing industry was developed.

Growth of the chemical industry in the Soviet Union took place at a highly accelerated rate. As a result of the industrialisation process the Soviet Union moved up from a backward industrial country to the second place in the world, behind only the United States of America.

In 1955, 19 per cent of the world's industrial products was manufactured in the U.S.S.R. In respect to the basic branches of the chemical industry the U.S.S.R. also occupied second place in the world, although the absolute difference in the volume of production of many chemical products as compared with the figures for the U.S.A. still remains large. The Sixth Five Year Plan provides for further accelerated growth of the chemical industry.

A major role in the development of the Soviet chemical industry was played by the scientists of the country. Since the very beginning of its existence the Soviet Government has been devoting much attention to the advancement of science. It began to build up a wide network of higher educational establishments and research laboratories which in later years played an important part in the scientific and industrial development of the country.

Progress in the fields of chemical science and industry is inconceivable without providing ever-growing numbers of highly qualified scientists and engineers. The training of personnel and the development of higher chemical education in our country was carried out bearing in mind not only the growing number of specialists required, but also the changes taking place in the nature of chemical industry and science.

The science of chemical engineering has undergone essential changes in the past several decades. It has

- 5 -

changed from a descriptive science to a synthesis of engineering subjects resting on a firm foundation of chemistry, physics and mathematics. The heart of the science of chemical engineering is the science of the basic processes and apparatus of chemical industries and the basic laws of chemical engineering processes. In meeting the needs of industry this science began its development towards its contemporary form and significance in the early twenties of this century in a number of countries, one of which was the U.S.S.R.

In the U.S.S.R. in fulfilling the requirements of industry and science for engineering and scientific personnel, a system was gradually developed consisting of training three principal types of specialists with higher education in the field of chemistry, -- 1/ chemists, university graduates, 2/ chemical engineers specializing in various fields, and 3/ mechanical engineers for chemical and other allied industries.

Already in the early years of its existence the Soviet Government adopted radical measures to promote higher education in this country with a view to training personnel in the various fields of science in considerable numbers. This was not an easy job, for pre-revolutionary Russia was a backward country with a very low cultural level of the major part of the population. More than two-thirds of the population was illiterate, and in the outlying regions of the country almost all the people were illiterate. Many peoples

6

inhabiting Russia did not even have their own written language. That is why the eradication of illiteracy in the first decade of the existence of the Soviet Government was an important step towards a cultural revolution in our country.

As compared with the advanced Western European countries in Russia higher education was at an extremely low level. In 1913 the entire country had only 136,000 specialists with higher education, the percentage of engineers and technicians among them being very small. In 1914, 16 Russian cities primarily in the European part of the country, had ¹⁰⁵ ~~105~~ institutes of higher learning with a student body of about ^{127,000} ~~127,000~~. Higher engineering education was an especially backward field. Russia had only 15 higher technical schools.

High tuition fees and an insignificant number of scholarships and many restrictions (regarding nationality, religion, etc.), made higher educational establishments inaccessible for the majority of the working people.

By a decree of August 2, 1918, the Soviet Government did away with all the obstacles to receiving higher education and opened the doors of higher educational establishments wide to all working people and their children, irrespective of sex, nationality, religion and property status.

The rapid development of the productive forces of the country, especially beginning with the period of

industrialisation, i.e. with the first five-year plan period /1928-1932/ created an enormous demand for specialists and led to a growth in the network of higher educational establishments, engineering schools in particular. The following figures illustrate the growth of general and special education in the U.S.S.R.

Whereas in 1914-15 the total number of persons studying in elementary, secondary and higher educational establishments was somewhat more than nine million, in 1955-56 the figure reached 33.9 million. In the same year in the Soviet Union there were 765 higher educational establishments located in 225 cities. The total enrollment was 1,867,000 including 639,000 correspondence course students. Besides this, 1,964,000 students were enrolled in 3,753 Soviet secondary technical schools. By January 1, 1956, the U.S.S.R. had 2,340,000 specialists with a higher education. By 1955, there were 585,900 engineers (28.8 per cent of the total number of specialists). The number of higher technical educational establishments reached 193.

A large network of higher technical educational establishments was developed in the National Republics of the Soviet Union and in the large industrial centres. The following data show the various branches of training and their specific weight in the general structure of higher technical education in the U.S.S.R.:

Groups of engineering professions	Specific Weight /in per cent/
1. Mining and geological	11.0
2. Energetics, radio-engineering, communications	14.7
3. Metallurgical	4.0
4. Machine-building and instrument manufacture, electrical machine- building.	33.0
5. Chemical technology ^x) (See p.9).	6.0
6. Food, textile, etc.	6.0
7. Construction.	16.0
8. Transport.	6.0
9. Others.	3.3

This structure is a result of the demand for engineering personnel in the various branches of industry in the U.S.S.R. The Soviet higher educational establishment enrolls students and graduates specialists in accordance with a plan which is included in the general national economic plan of the U.S.S.R.

Chemical engineers and university trained chemists account for a high percentage of the specialists graduating from the higher technical schools. In pre-revolutionary Russia there were only a few hundred Russian chemists with higher education. The training of chemists and chemical engineers was conducted in eight higher technical educational establishments and seven universities, and the number of graduates was extremely small.

x) To a certain extent chemical technology is included in the groups mining and geological /chemical technology of petroleum/, metallurgical (coke even by-products chemistry/ and construction /building materials technology/.

- 9 -

After the revolution training of specialists in the field of chemistry was conducted on a large scale and the number of chemists with a higher education increased to tens of thousands. Many the country has ten specialized chemical technology institutes preparing engineers for the various branches of the chemical industry and the building materials industry. They include such major educational establishments as the Leningrad Technological Institute, the Mendeleev Chemical Engineering Institute, Moscow, the Kazan and Dnepropetrovsk Chemical Engineering Institutes and others. The Moscow Institute of Chemical Machine Design and mechanical departments of some chemical engineering institutes train mechanical engineers for the chemical and chemical machine building industries. A number of institutes have evening and correspondence courses which enable plant workers to receive a higher education in their spare time.

As an illustration of the scale on which chemical engineers are trained in the Soviet Union can serve the fact that the Mendeleev Chemical Engineering Institute, Moscow, has alone graduated over 11,000 chemical engineers during the thirty-seven years of its existence. An even larger number of specialists was trained over the same period at the Leningrad Technological Institute which in December 1953 marked its 125th anniversary.

Besides this, chemical engineers are trained at 13

-12-

Besides this, chemical engineers are trained at 13 specialized technological institutes for the food, textile and leather industries, at three petroleum and four metallurgical institutes. A large number of chemists are graduated from chemical departments of universities and polytechnical institutes in Moscow, Leningrad, Kiev, Kharkov, Dnepropetrovsk, Kazan, Tbilisi, Yerevan, Baku, Tashkent, Sverdlovsk, Tomsk and other cities. Twenty-seven of the country's thirty-three universities and 19 of its 25 polytechnical institutes have chemical departments.

University chemical departments graduate in the main research workers and teachers; the major part of the university graduates are employed as teachers in secondary schools. The training of chemistry teachers for secondary schools is also carried out on a large scale at the natural science departments of many pedagogical institutes. Eight pharmaceutical institutes in various cities train chemists for the pharmaceutical industry and for work in pharmacies.

The following table provides information on the enrollment of chemical students and the plan for graduating specialists from the U.S.S.R. higher schools during the Sixth Five-Year Plan.

**Student Body and Engineering Graduates in the Field of
Chemistry for U.S.S.R. Higher Educational Establishments**

Kind of Engineer.	Student body on Sept. 15, 1956.		Sixth five-year plan.	
	Day Stu- dents.	Total in- cluding evening & corres- pondence course students	Day Stu- dents.	Total in- cluding evening & corres- pondence courses students
1. Chemical engineers	37,190	50,768	33,030	36,445
2. Mechanical engineers for the chemical industries	7,234	10,560	7,045	8,110
3. Chemists with a university education	9,110	9,199	8,550	8,550
4. Others, including: geochemists, soil experts and eco- nomists for the chemical and allied indus- tries.	4,740	6,073	4,825	5,226
TOTAL	58,274	76,600	53,450	58,331

- 12 -

Chemical engineering students specialize in the following fields:

a) chemical engineering, including the following special fields:

- 1) inorganic substances,
- 2) electro chemical processes,
- 3) rare and dispersed elements,
- 4) silicates,
- 5) petroleum and gas,
- 6) solid fuels,
- 7) basic organic synthesis and synthetic rubber,
- 8) dyes and intermediate products,
- 9) pharmaceuticals and perfumes
- 10) plastics,
- 11) varnishes and paints,
- 12) rubber,
- 13) cinema and photo materials,
- 14) electrical vacuum industry materials,
- 15) technology of radio-active elements,
- 16) technology of separation and utilization of isotopes,
- 17) other chemical substances and
- 18) chemical kinetics and combustion.

b) Technology of wood pulp and paper.

c) Foodstuffs technology, including the following special fields:

- 1/ baking and confectionary processes,
- 2/ technology of sugar products,
- 3/ fermentation processes,
- 4/ wine making,
- 5/ animal fats and vegetable oils.

d) Consumer goods technology, including the special fields:

- 1/ chemical technology of fibre materials,
- 2/ artificial fibres and
- 3/ artificial leather.

-13-

Students of mechanical engineering for the chemical industries specialize in exploitation and design of chemical apparatus and machines for the chemical industry and allied industries.

University chemical departments train scientists specialized in one of the basic fields of chemistry: general and inorganic chemistry, analytical chemistry, organic chemistry or physical chemistry. In addition, some universities graduate specialists in geochemistry, soil chemistry and agricultural chemistry, and chemical engineering institutes graduate economists for chemical and allied industries.

METHOD OF INSTRUCTION.

The curriculum for chemical engineering and mechanical engineering students can be divided into the following groups of subjects:

1/ social sciences and economics--fundamentals of Marxism, Leninism, philosophy, political economy, economics of industry and organization of production;

2/ physico-mathematical sciences-- mathematics, physics and theoretical mechanics;

3/ chemistry sciences--inorganic, organics, analytical, physical and colloid chemistry;

4/ mechanical engineering subjects--descriptive geometry, engineering drawing, strength of materials, theory of mechanisms and machines, machine design, heat power engineering, structural

engineering, sanitary engineering;

5/ chemical engineering subjects -- industrial chemistry.

basic processes and apparatus of chemical engineering, automation

instrumentation of chemical plants, safety engineering, corrosion of metals, etc.;

6/ special field subjects -- chemical technology of the special field and theory of technological processes and equipment of plants in the chosen field;

The following table provides data on the number of subjects, total study hours and specific weight of the various groups of subjects in the curriculum.

Group of subjects.	No. of Sub-jects	No. of hrs.	Specific Weight /in per cent/
1. Social sciences, economics and humanities	5	624	12.0
2. Physico-mathematical sciences	3	660	14.0
3. Chemistry	5	1,110	25.0
4. Mechanical engineering subjects	7	844	10.0
5. Chemical engineering subjects	4	452	10.1
6. Special field subjects	5	600	13.6
7. Physical training and sports.	1	136	3.2
TOTALS	30	4,426	100.0

In chemical engineering institutes and chemical engineering departments of polytechnical institutes, the curriculum for the first three and one half years are almost identical for all students specializing in related fields. Only in the last one and a half or two years do the students begin the study of subjects in the selected fields, at the same time continuing to study basic sciences and general engineering subjects. Along with final plant practice and work on a diploma design, these subjects in the special field provide the student with the essential knowledge in that field.

Soviet higher technical educational establishments employ the following forms of instruction: 1/ lectures, 2/ laboratory studies, 3/ practical studies, 4/ end term designs and calculations, 5/ plant practice and educational practice, 6/ consultations, 7/ diploma design and diploma research problems 8/ independent work of students. The term of study in engineering schools and chemical departments of universities ranges from five to five and a half years. The total number of obligatory hours over that period depends on the ~~term~~ duration of plant practice and on the length of the term of study and comprises from 4,000 to 5,000 hours.

Engineering students have three periods of plant practice during their course of study. They are: 1/ general engineering plant practice at the end of the sixth term /lasting four weeks/; 2/ technological plant practice at the end of the eighth term /lasting eight weeks/; 3/ final plant practice at the end of the ninth term /lasting eight weeks/.

3/ final plant practice at the end of the ~~ninth term~~ ^{plant} lasting eight weeks/. The best chemical plants in the corresponding field are selected for the students practice.

During their general engineering and technological ^{plant} practice the students work at various jobs in/shops, study the equipment and technological processes, take examinations for certification as qualified workers /operator, turner, fitter or the like/, and also study the organization and economics of the production processes. During their final practice the students collect data necessary in carrying out their diploma design.

The aim of the educational practice, which is conducted in the school's workshops, is to acquaint the students with the machines for working metals, wood, plastics, etc., and to teach them to operate such machines.

At the end of their course of study engineering students carry out a final diploma design. In chemical engineering schools students who show special interest in research may have the diploma design replaced by a diploma research problem in the student's special field. Research on diploma problems is occasionally carried out in industrial research laboratories. Students who carry out diploma research in addition to it are obliged to submit an extended end-term design connected with one of the major technological processes. The diploma design consists of a design of a shop or of a plant in the selected field.

- 17 -

Mechanical engineers for the chemical industry take their plant practice at machine building plants. Plant practice at chemical plants for university students is shorter than for engineering students and lasts from one and a half to two months.

All students are obliged to fulfil small end-term problems consisting of a written review of the literature on some subject or of a research problem. The diploma research problems are small laboratory research projects in the student's chosen field.

Graduating students defend their diploma designs or diploma research before a state examination commission made up of professors and teachers in higher educational establishments and of representatives of the corresponding branches of industry.

Correspondence course students and students of evening schools and of special evening departments of day schools have a six year term of study. Evening school students attend the higher technical school four times a week and during four hours they listen to lectures and work in laboratories and study rooms.

The curriculum for mechanical engineers allocates more time to physical-mechanical and engineering sciences than to chemical subjects, while the study plan of university chemical departments entirely excludes the engineering subjects and devotes more attention to the basic chemical subjects than in chemical engineering institutes.

- 18 -

TRAINING TEACHING AND RESEARCH PERSONNEL

In the Soviet Union there are two academic degrees which are awarded to research workers. They are Candidate of Sciences and Doctor of Sciences in a definite field of science /physico-mathematical, technical, chemical, historical, medical, philological, etc./. The first scientific degree is that of Candidate of Sciences. It is conferred on persons with higher education who have passed their Candidate examinations and defended a research thesis before the Academic Council of a higher educational establishment or a research laboratory. The Doctor's degree is granted to possessors of a Candidate's degree after they have defended their doctor's research thesis. Candidates of Sciences examinations cover four subjects: one general, theoretical subject, one special field subject, a foreign language and philosophy. On October 1, 1955, the Soviet Union had 223,900 scientists, of them 119,100 worked in higher educational establishments /in 1916 Russia had only 6,655 scientists/. Among these scientists there were 9,500 Doctors of Sciences and 78,000 Candidates of Sciences, including 626 Doctors and 4,639 Candidates of Chemical Sciences. (Doctors and Candidates in the chemical engineering field receive degrees as Candidates and Doctors of Technical Sciences).

As these figures show, in the Soviet Union the doctor's degree is awarded to only the most outstanding of these scientists.

- 19 -

Research and pedagogical workers of higher educational establishments are classed as professors, docents or assistants. At the present time there are 9,000 professors and 23,000 docents. Training of scientific personnel is carried out by means of post-graduate courses at higher educational establishments and research laboratories. Many research and pedagogical workers defend advanced degree theses without taking post-graduate courses, carrying out the necessary research independently.

In connection with new developments in chemical sciences and industry higher educational establishments ~~have~~ are continuously confronted with new tasks that call for various changes in the training of specialists, such as altering the training programme in the various special fields, introducing new special fields, changing methods of teaching or curricula, expanding laboratory facilities, etc. These changes are often connected with certain difficulties and are aimed at overcoming existing defects.

Such, in brief, are the far from complete data on achievements made and the contemporary condition of higher chemical education in the U.S.S.R.

The workers in the Soviet higher schools are interested in the working of foreign universities and colleges and utilize the experience of the foreign schools for further improving the training of specialists in the U.S.S.R. On the other hand, they gladly share their own experience with scientists of other countries.